

Clifford V. Johnson, USC

String Theory

Organized by:
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William A. Zajc, Columbia

Discussant:
Glennnda Chui,
Symmetry Magazine

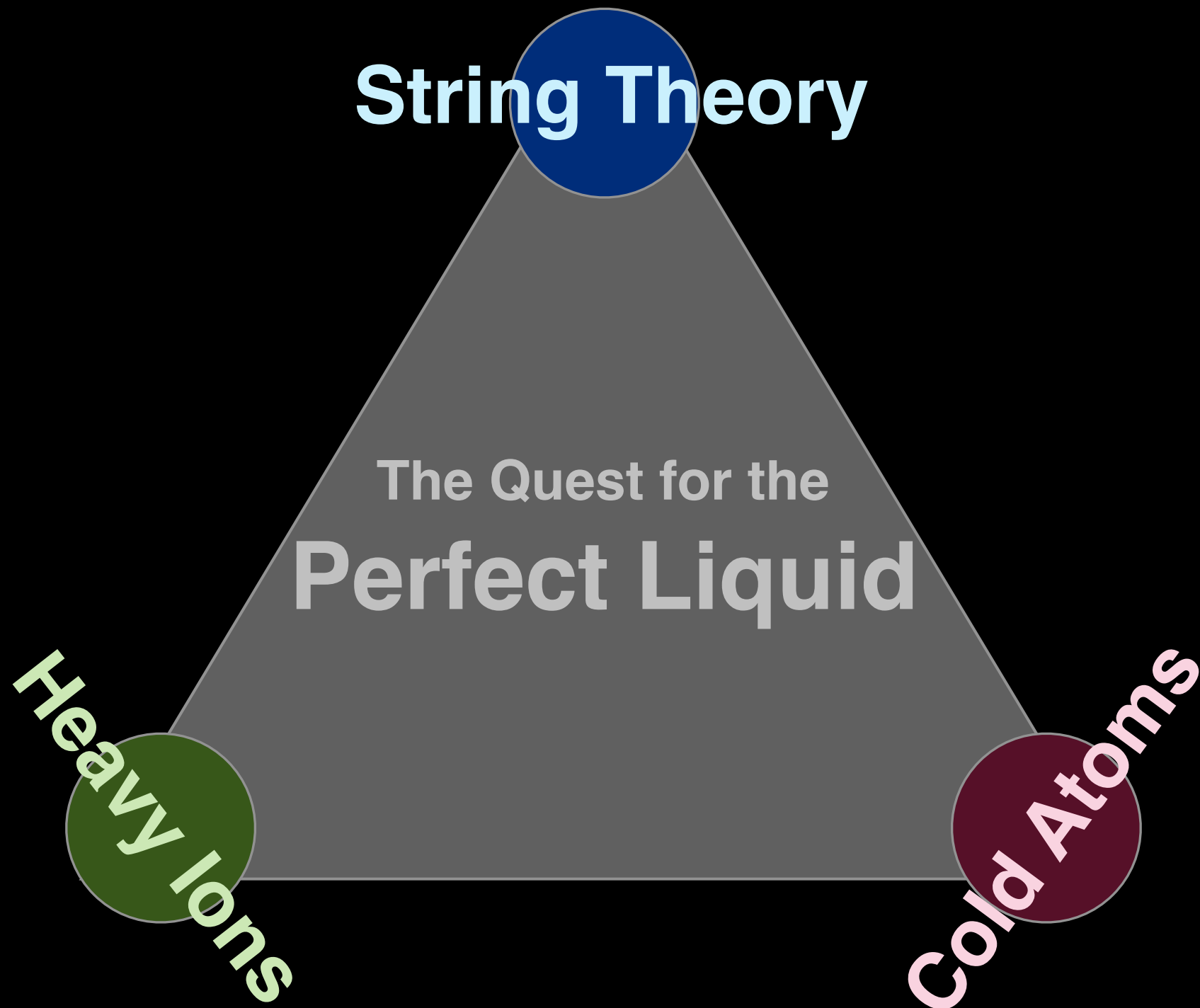
The Quest for the
Perfect Liquid

BROOKHAVEN
NATIONAL LABORATORY

Heavy Ions

Barbara Jacak,
Stony Brook University

Cold Atoms
John Thomas,
Duke University



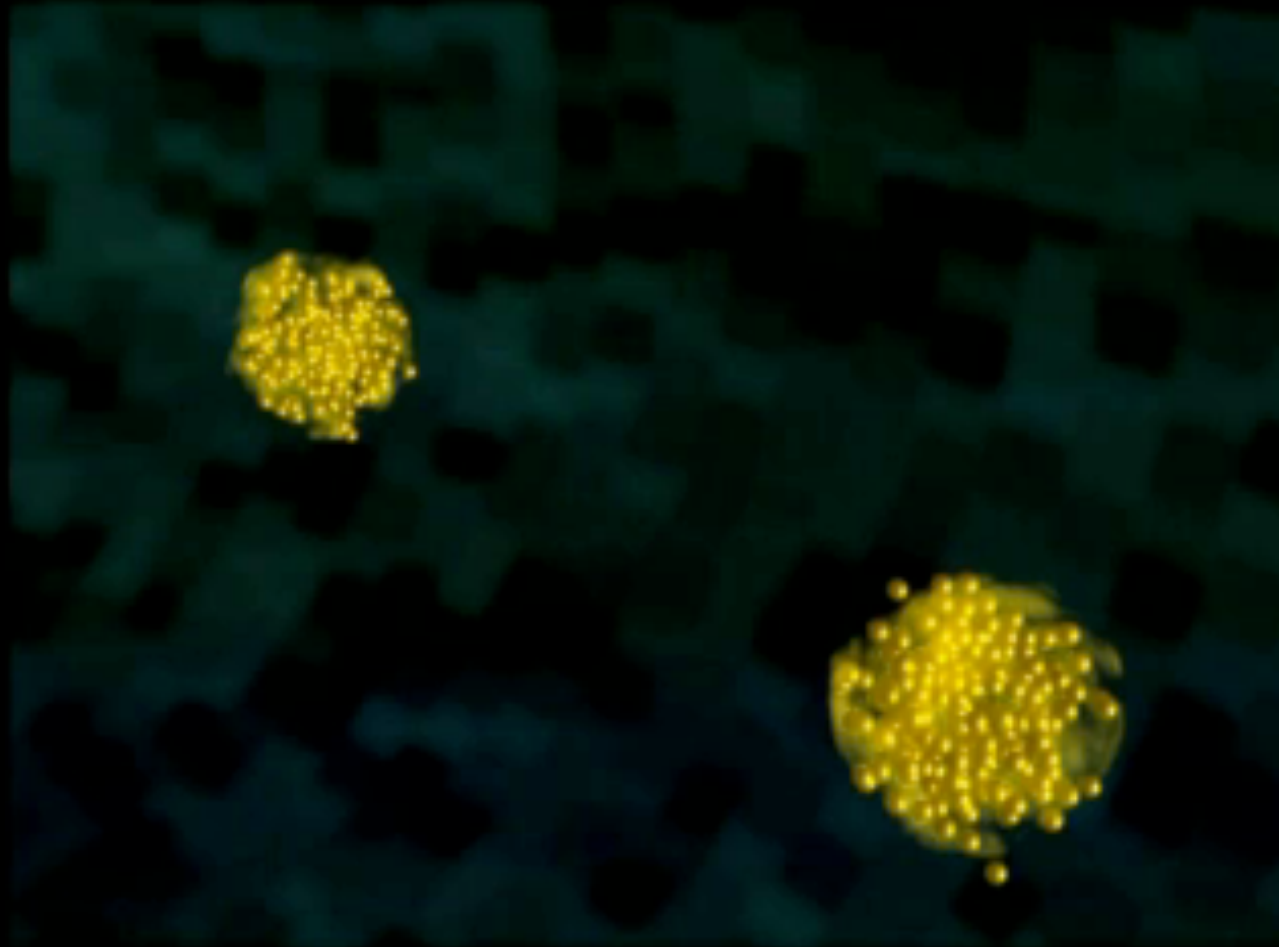
3 scientific communities come together in a 5 dimensional world



Heavy Ions

RHIC collides gold ions at highest energies available in the lab.

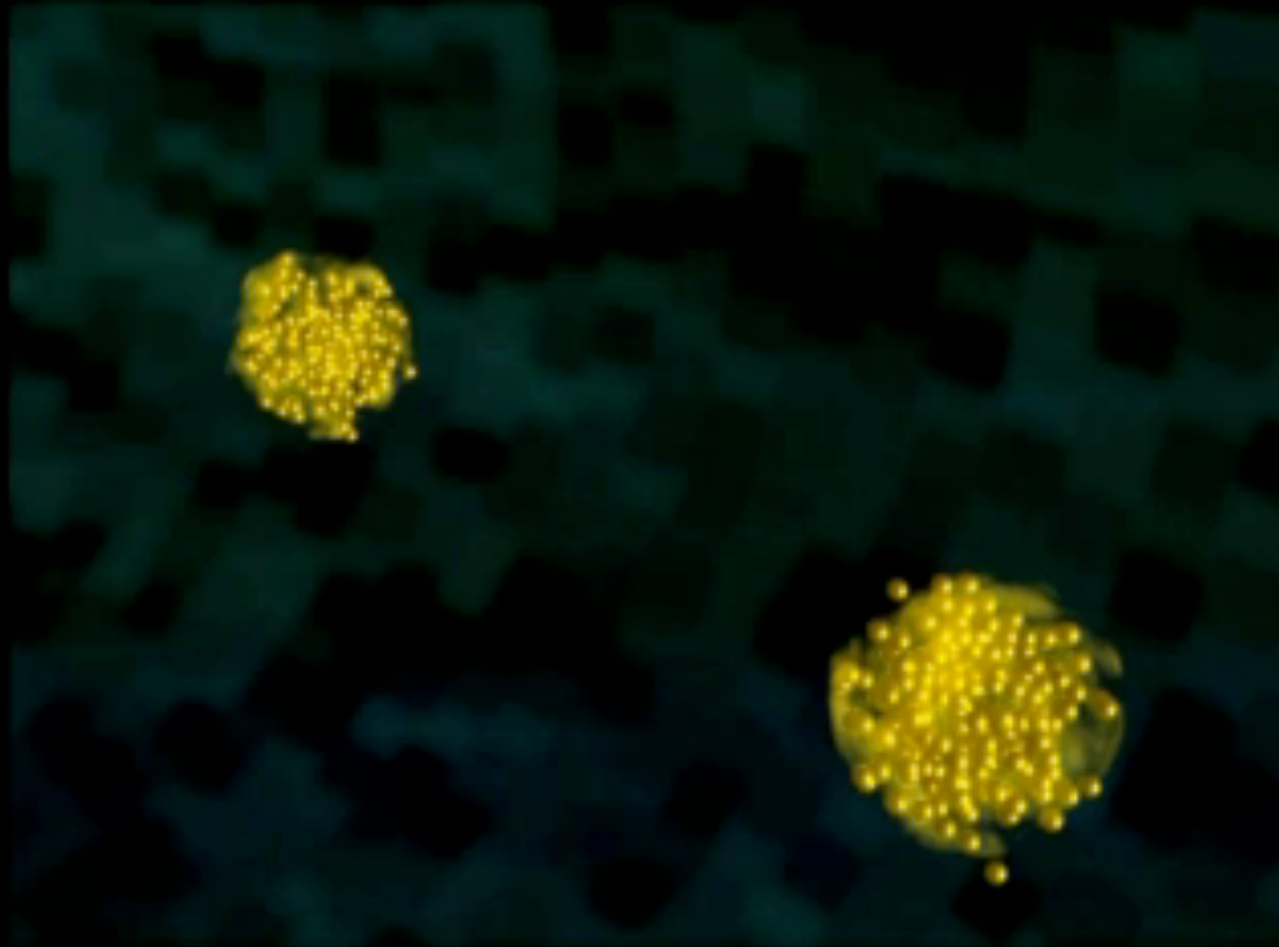
“Ultrarelativistic”: $E=mc^2$ turns 400 nucleons \rightarrow 10000 particles, likely via “quark-gluon plasma” (QGP)



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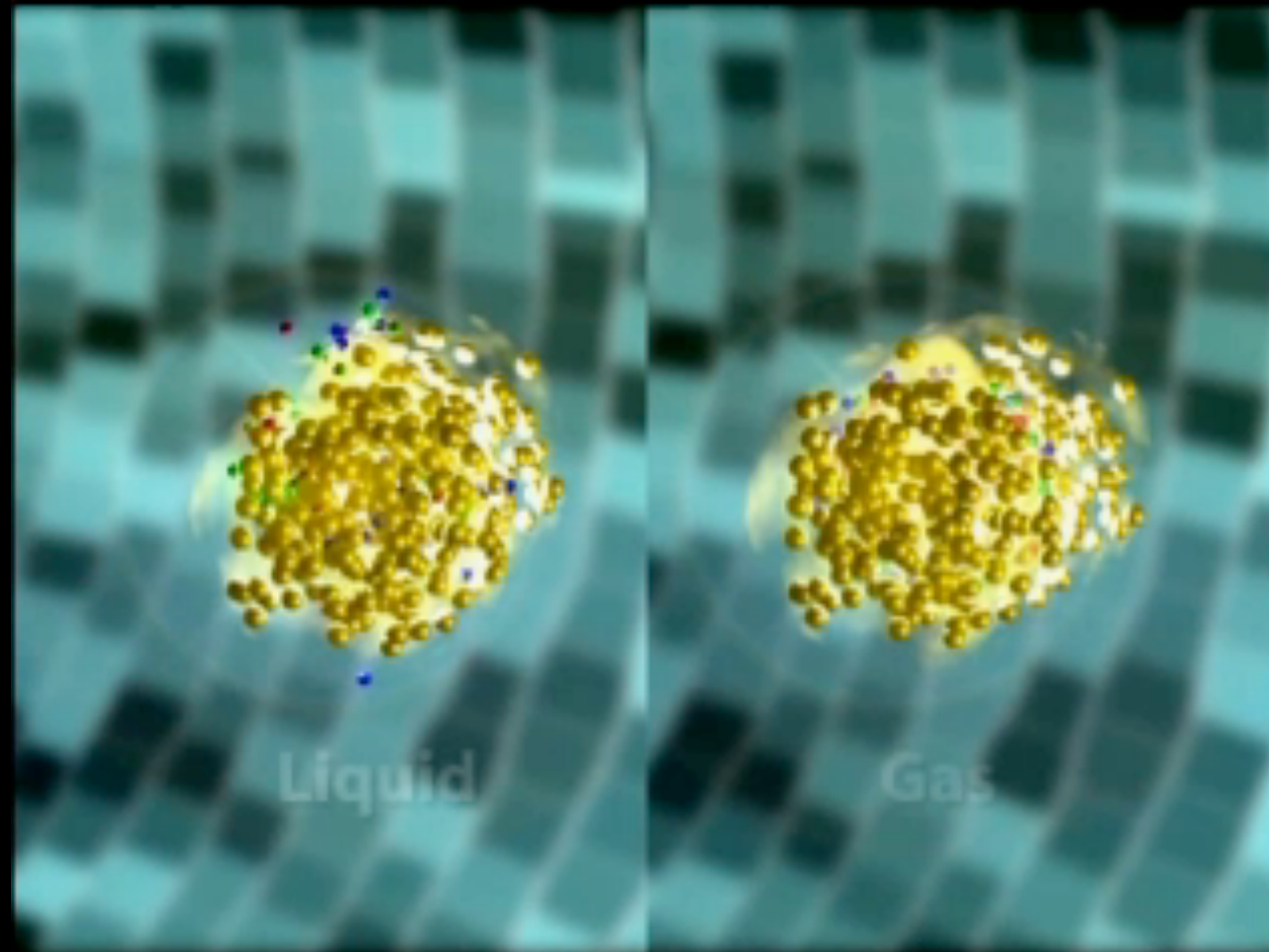
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} 10^{-14}m

Heavy Ions

Data show that RHIC creates
drop of matter of size $\sim 10^{-14}\text{m}$
→ particles are strongly-coupled

Compressed shape → sideways flow
characteristic of liquid (not gas)
→ 2005 discovery of “perfect liquid”



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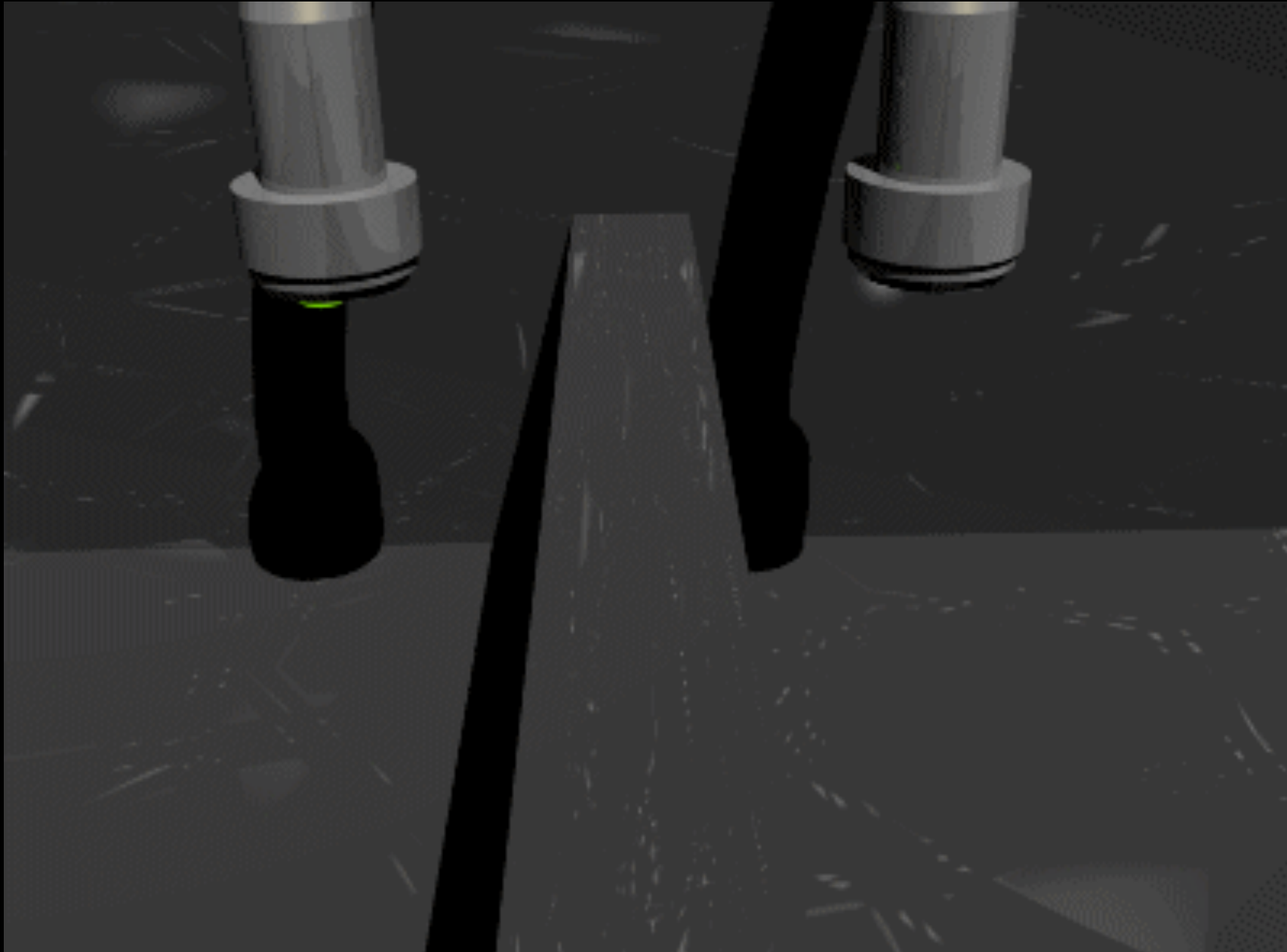
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how can a liquid be “perfect”?

en.wikipedia.org/Viscosity



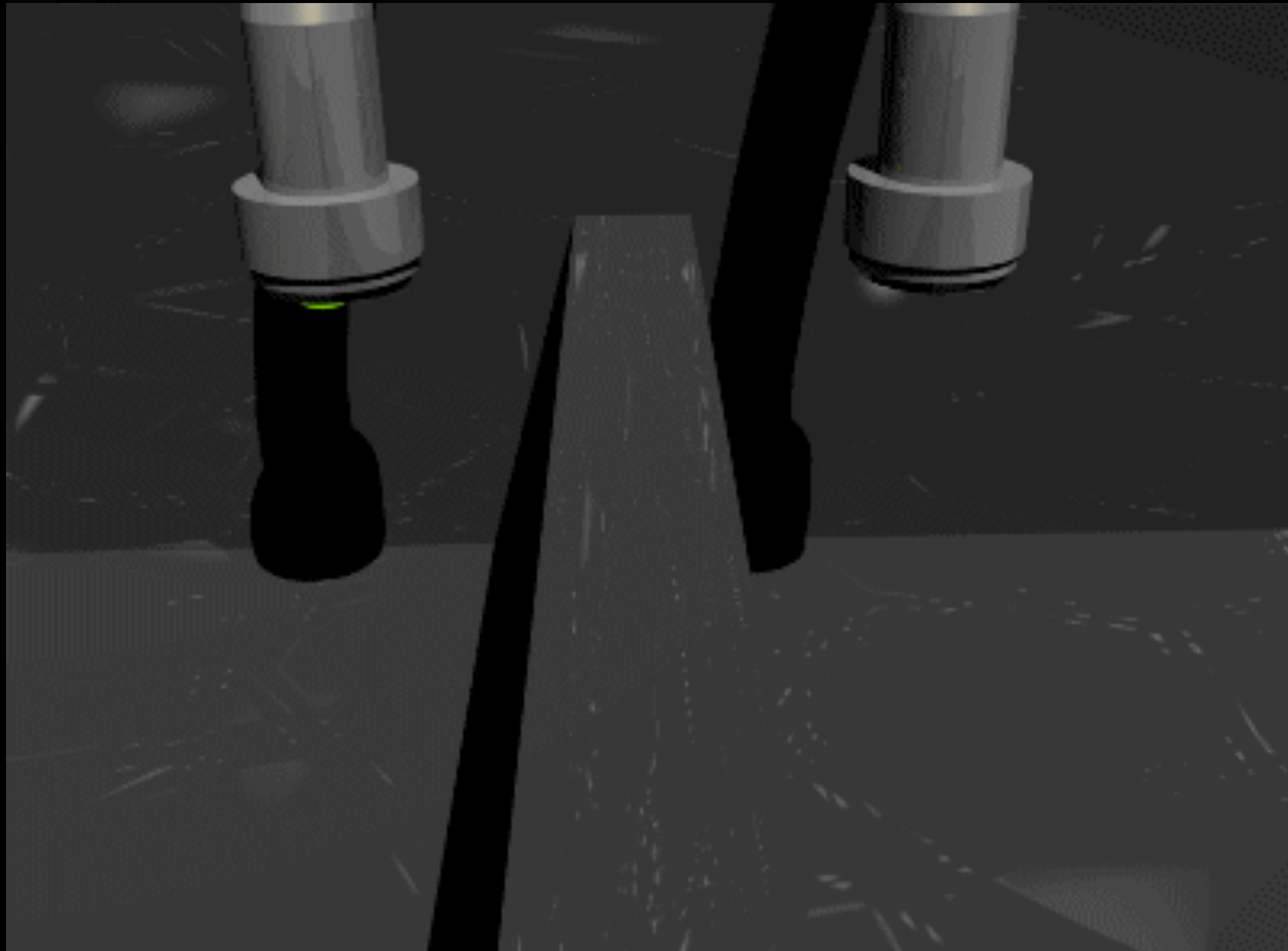
high viscosity (e.g. honey)

low viscosity (e.g. water)

how can a liquid be “perfect”?

en.wikipedia.org/Viscosity

low
resistance
to flow



propagates
ripples

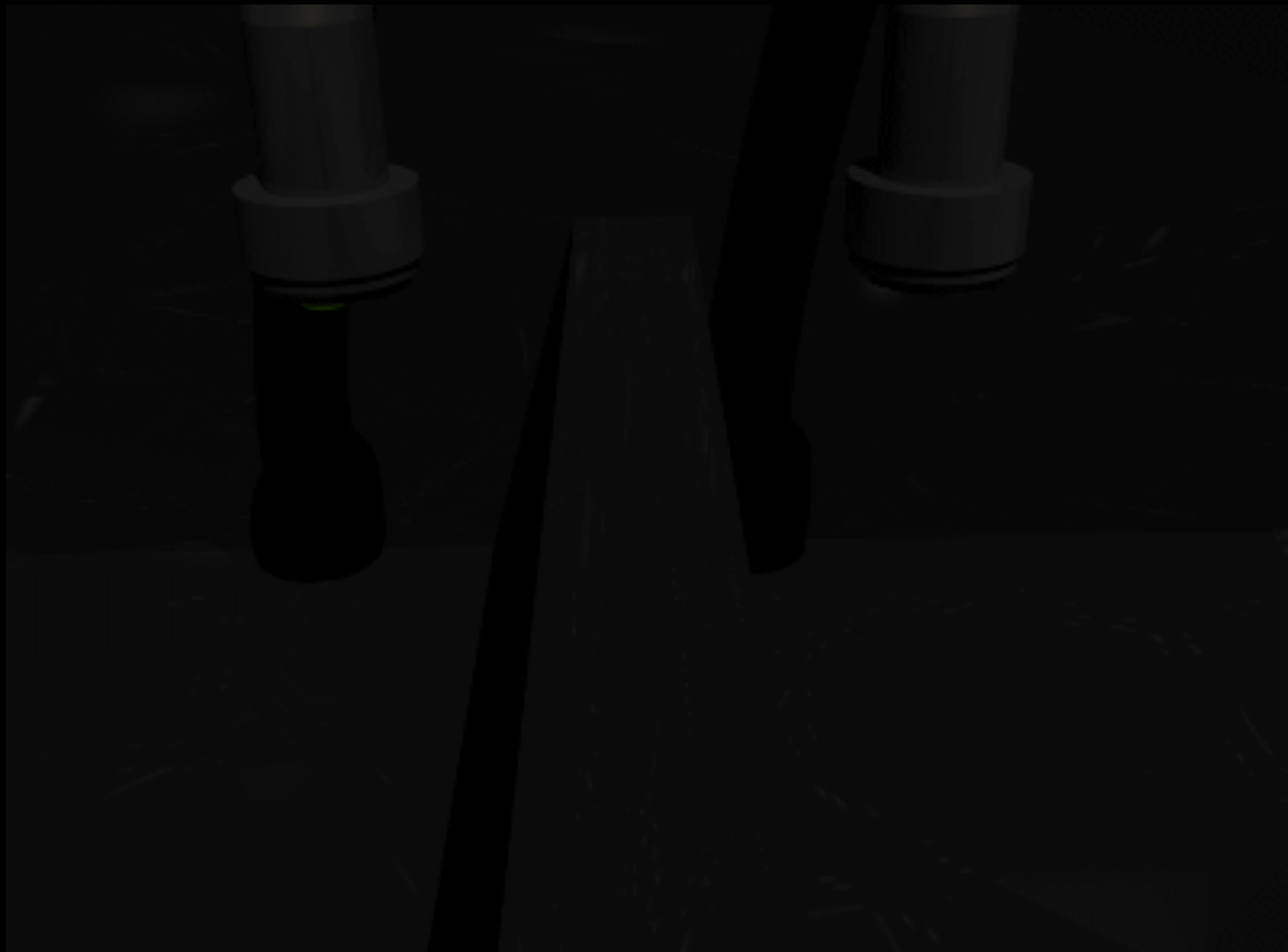
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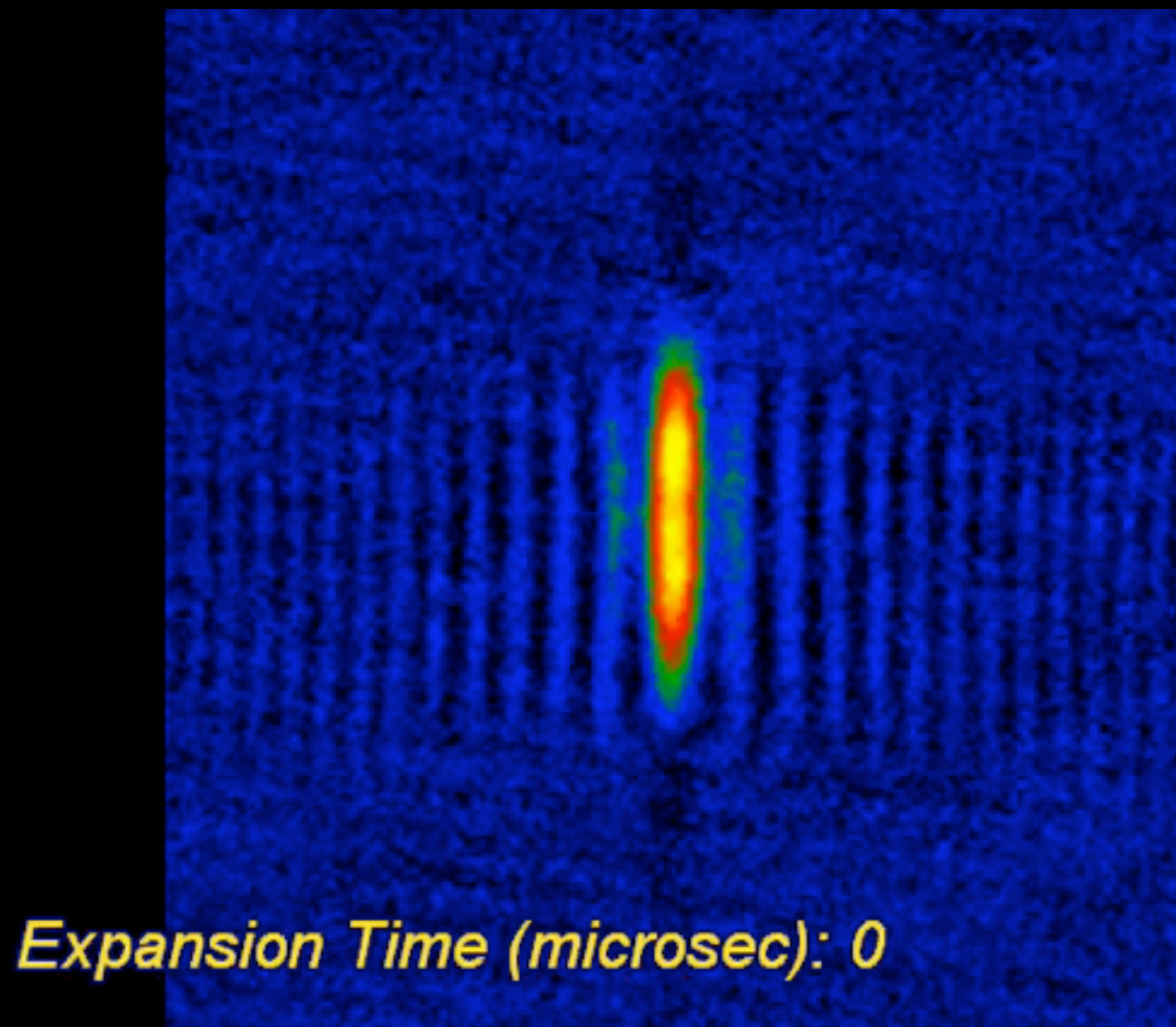
most perfect liquid has minimum viscosity

Gas of cold Li atoms at strong coupling:
this “gas” also flows like a perfect liquid

} 10^{-5}m (nearly a billion times
smaller than RHIC!)

Cold Atoms

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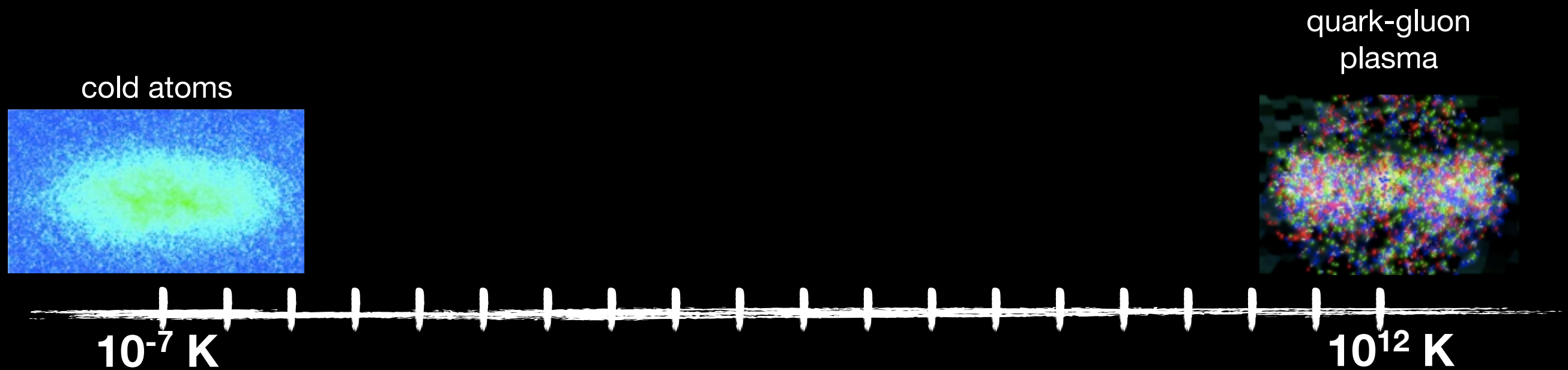
Cold Atoms

273 K = 0°C



two nearly perfect liquids, completely different scales

273 K = 0°C



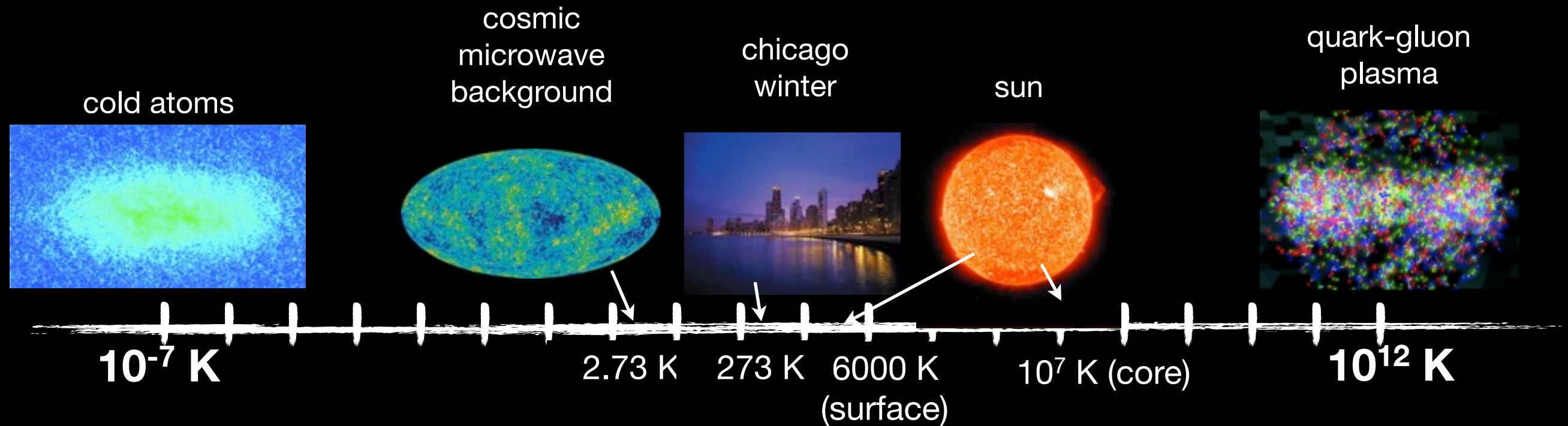
two nearly perfect liquids, completely different scales

difference in temperature : 10 billion billion (10^{19})

difference in volume : 1 million billion (10^{15})

difference in density : 10 million billion billion (10^{25})

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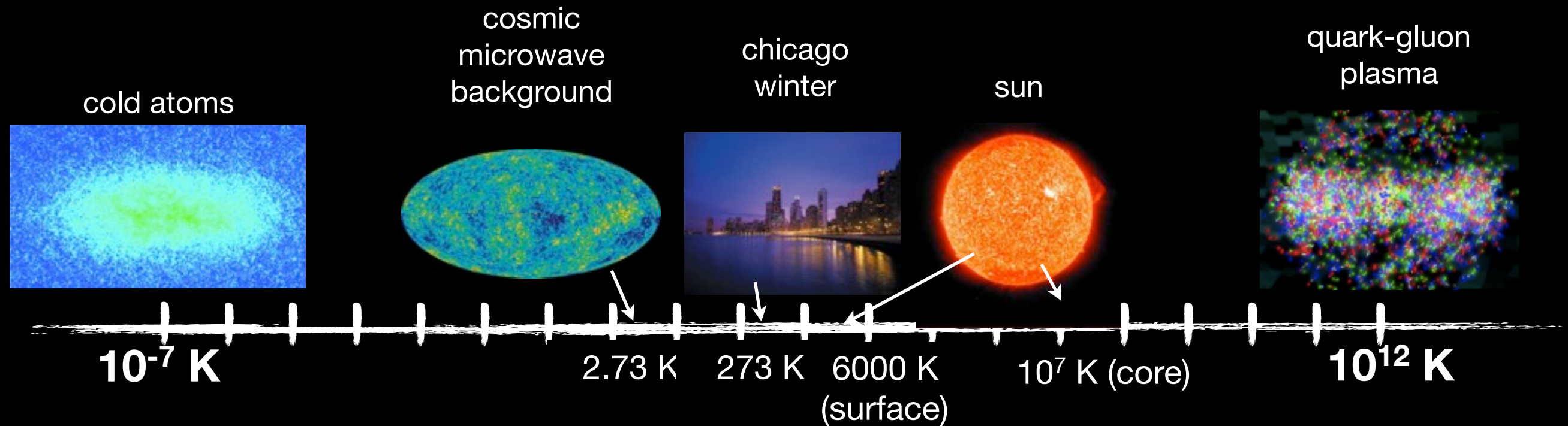
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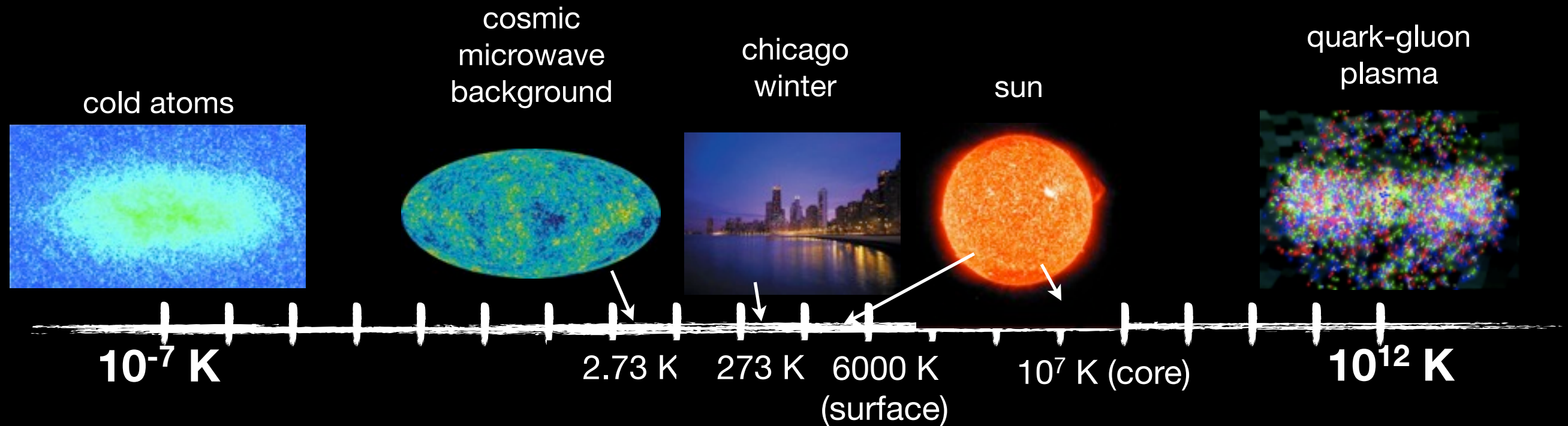
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perfect liquid is independent of scale

$$273\text{ K} = 0^\circ\text{C}$$



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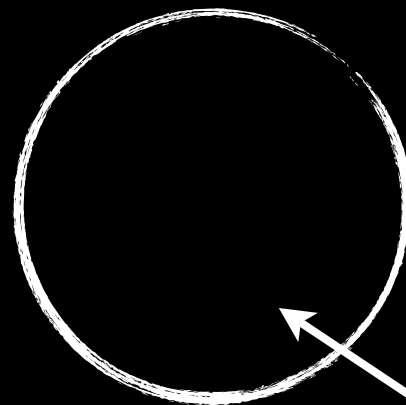
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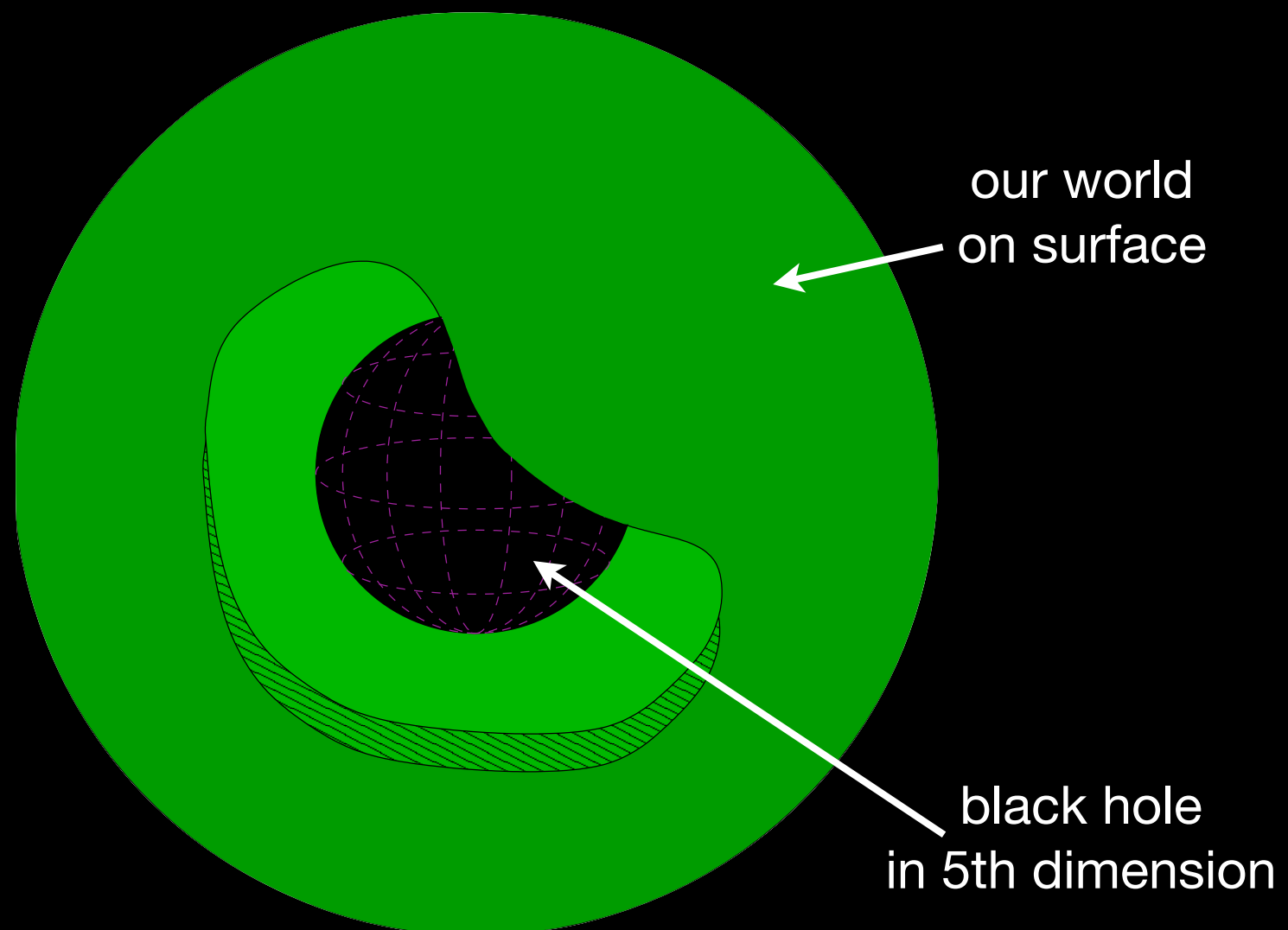
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String Theory

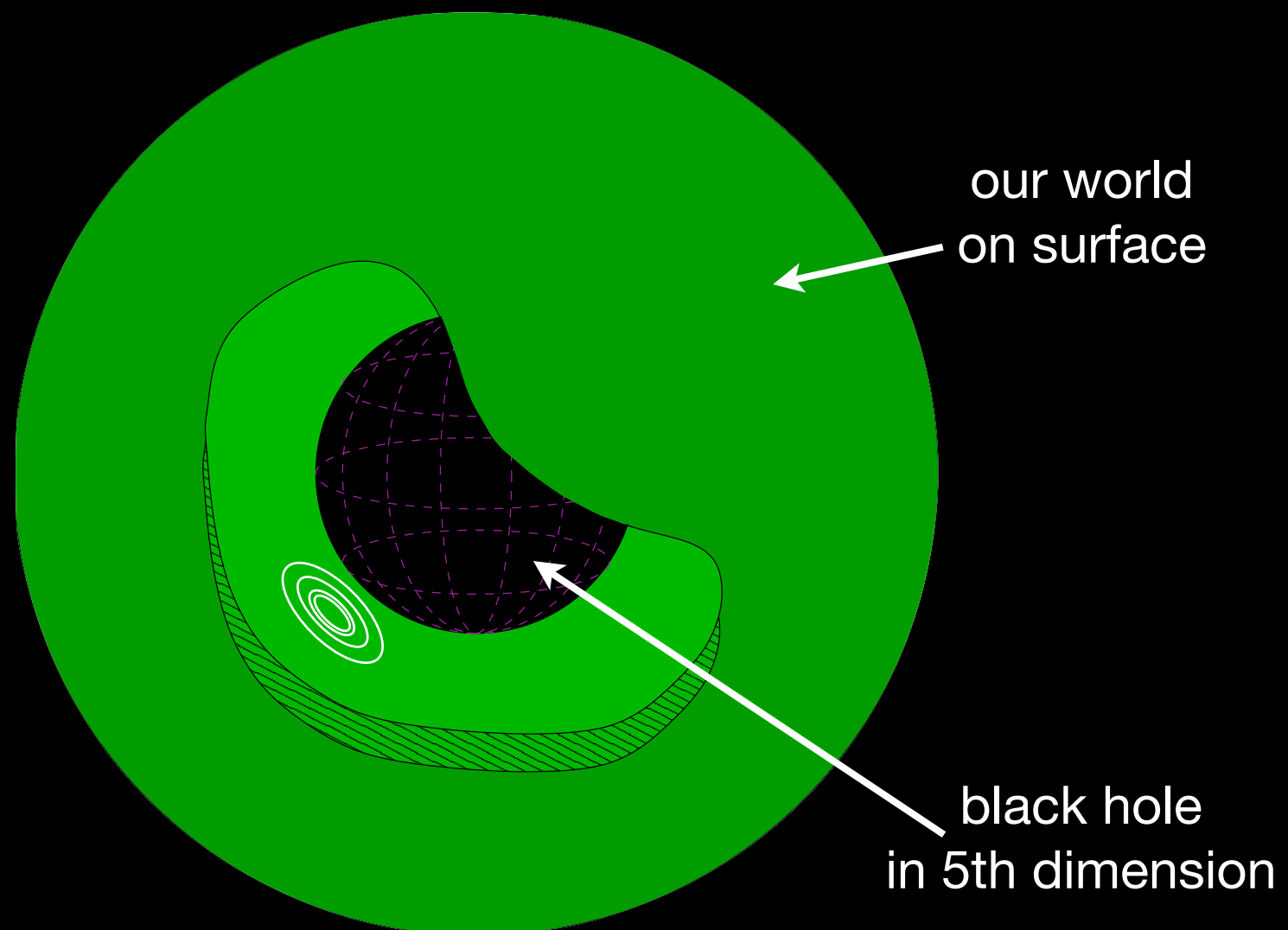


black hole
in 5th dimension

String Theory

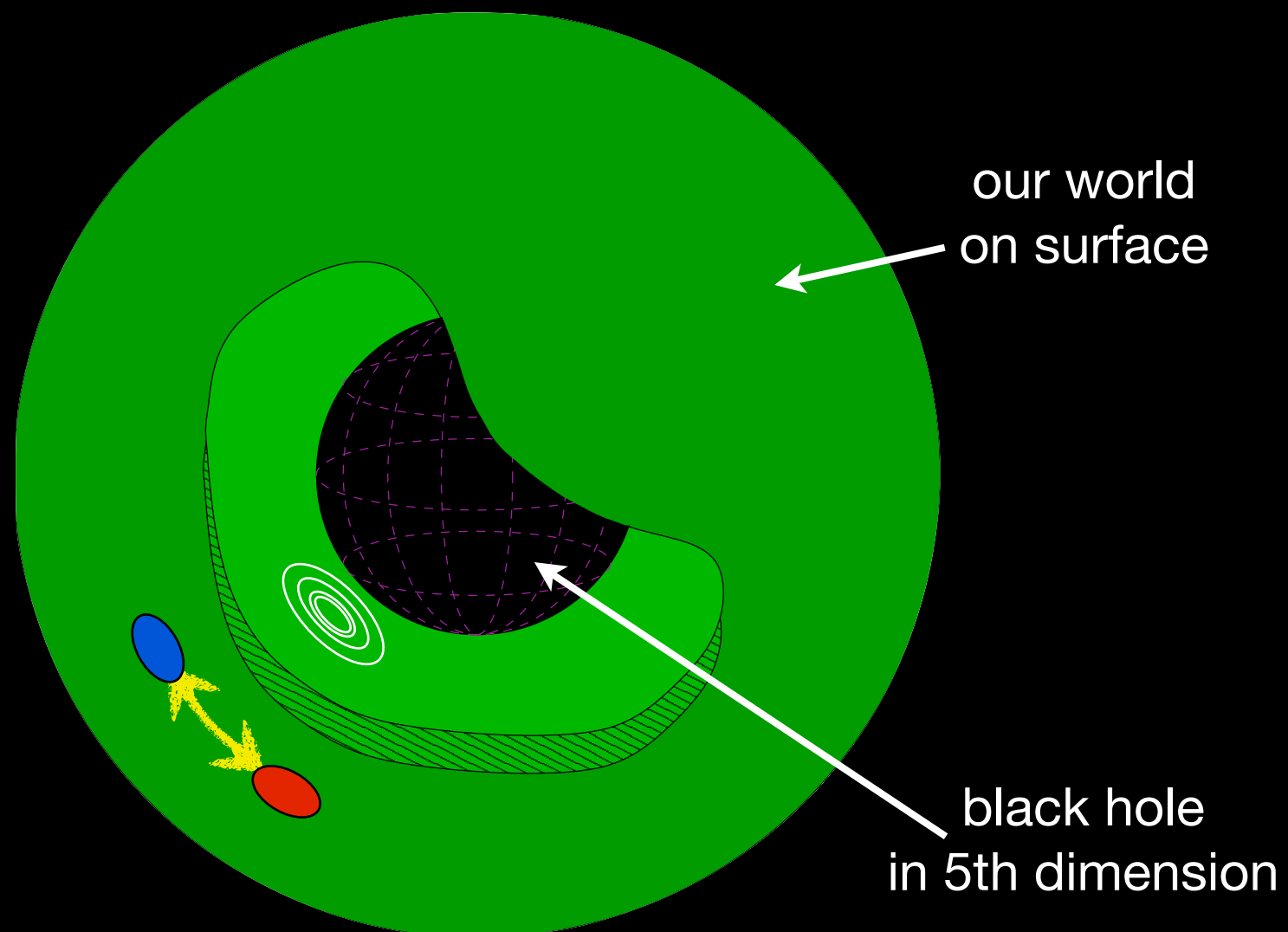


String Theory

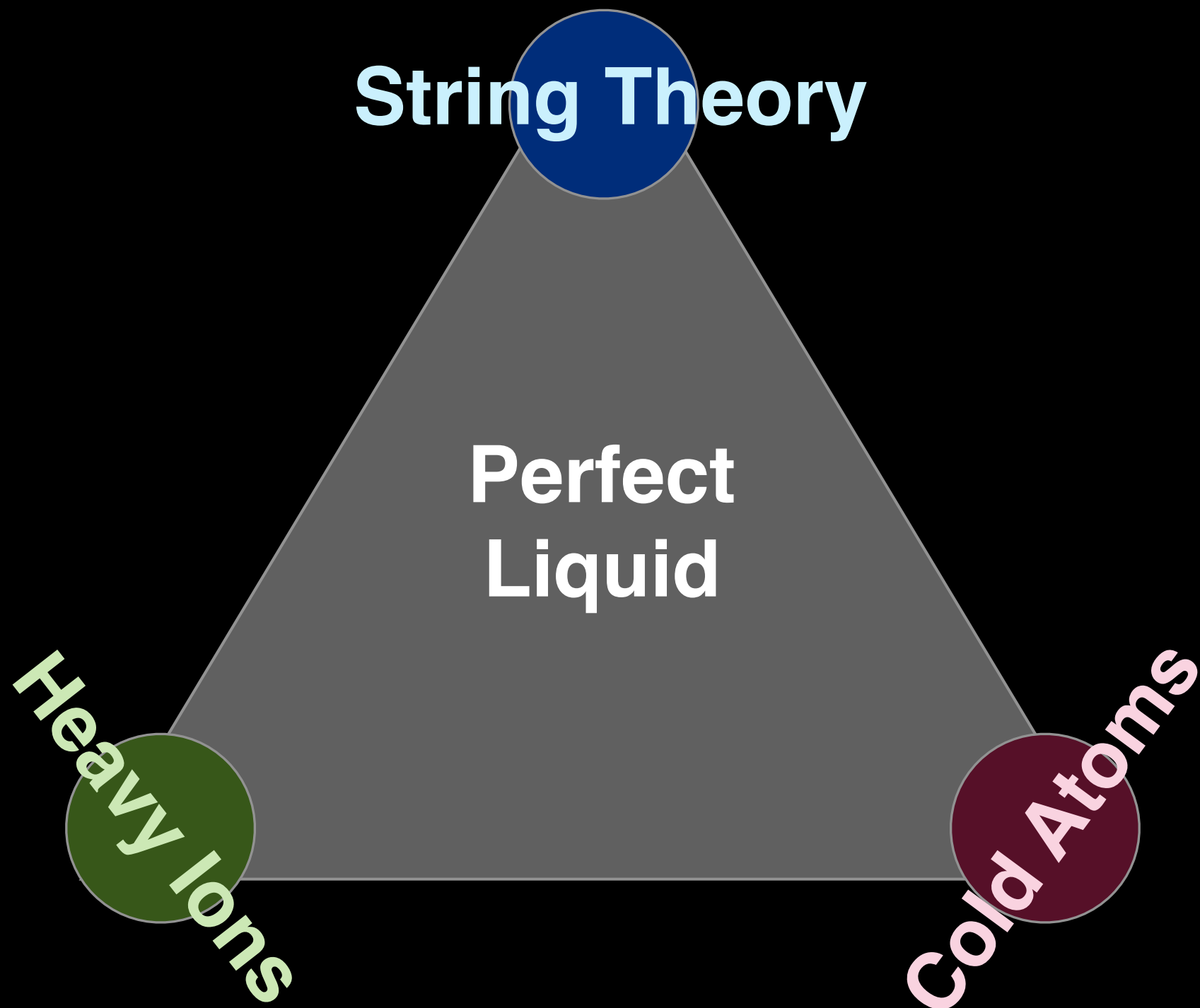


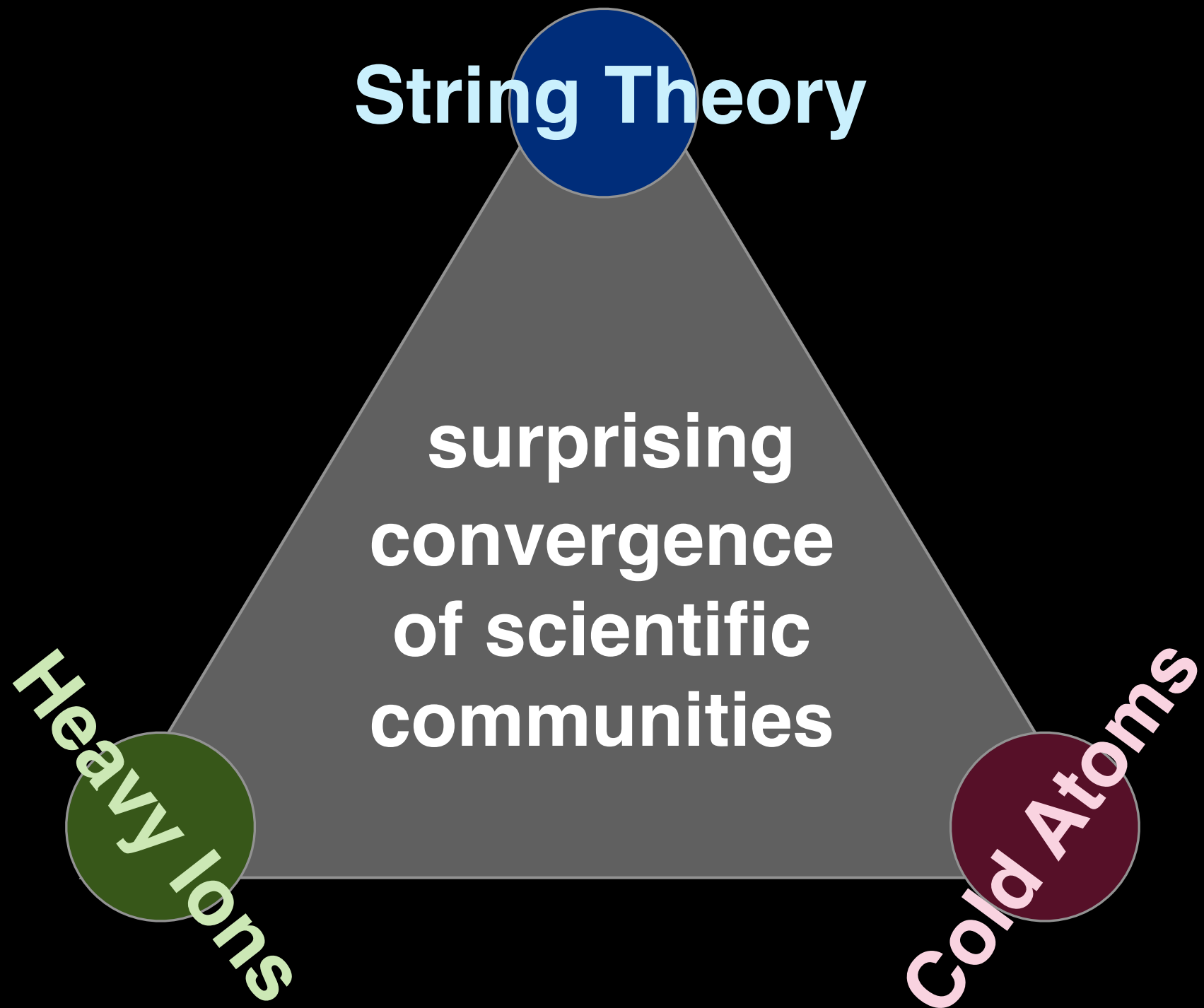
Ripples in the fifth dimension, controlled by black hole:

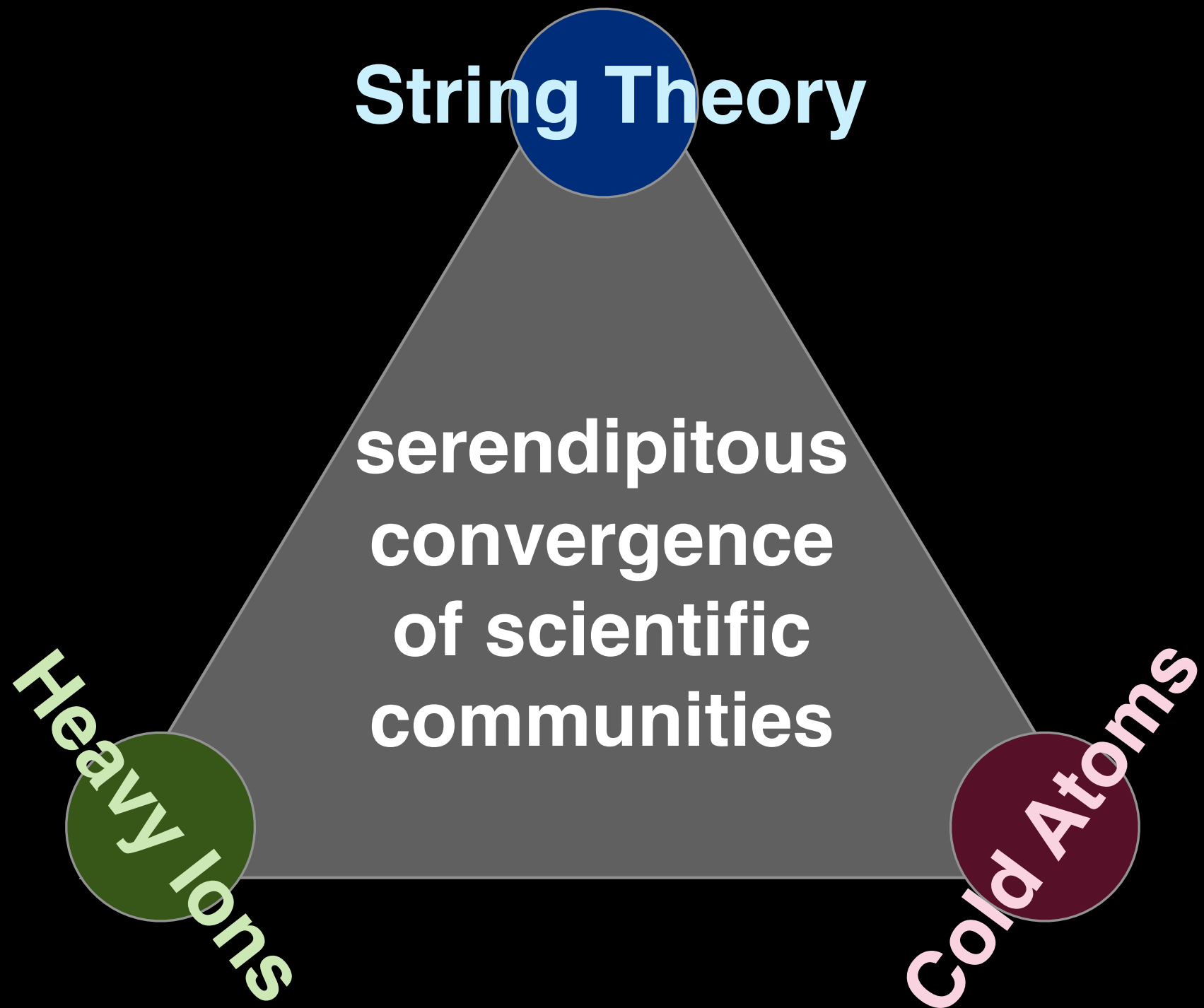
String Theory



Ripples in the fifth dimension, controlled by black hole:
interactions between quarks & gluons...or cold atoms







Clifford Johnson, USC

String Theory

**serendipitous
convergence
of scientific
communities**

Heavy Ions

**Barbara Jacak,
SUNY Stony Brook**

Cold Atoms
John Thomas, Duke

